International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 14, Issue 9, 2020

Working Towards a Universal User Interface Design of Mobile Applications for Elderly Users: An Arabic Case Study

Ahmed Alsswey[1], Khaled abuhmaidan[2], [1]Multimedia Technology Department, AL-Zaytoonah University of Jordan, [2]Department of Computing and IT, Global College for Engineering and Technology, Muscat, Oman, Email: [1]Ahmad_suwwi@yahoo.com, [1]a.alsswey@zuj.edu.jo, [2]kabuhumaidan@yahoo.com

The rapid growth in the number of elderly people globally has inspired researchers in human-computer interaction (HCI) to design technologies that enhance their life. The present user interface (UI) of web pages, applications, systems and electronic devices have design issues concerning usability and accessibility for the elderly users which hinder them from using technology at an optimal level. This is particularly true for the elderly users utilising mobile applications for the first time or who have little experience in using them. As people need to access and use information at a much faster rate and at their fingertips, a user interface design that meets their demands and satisfies the concerns of all user groups is vital. This paper covers the limitations faced by elderly users associated with aging such as visual, cognitive and memory impairments and the required design for successful applications. It also describes the interface design elements for these users by suggesting guidelines for developers and interface designers to overcome these limitations. A total of 124 participants were recruited to generate the design guidelines for this study. The results showed colour, font, icons, language, button information architecture and multimedia are the most important UI elements.

Keywords. *Elderly Users, User Interface, UI Elements, Mobile Application*

Introduction

Currently, rapid growth of elderly people is a global phenomenon. Approximately 10% of the world's population is aged 60 years and above, and the percentage is expected to rise dramatically by 2050. The aging population faces many challenges in different fields such as services,

technology and how to improve it in order to enhance their health and quality of living (Roupa et al., 2010). In this context, the user interface of technology, for instance, systems and applications, are viewed as having enormous potential. Technologies for the elderly are a major field of research and development (Neves & Vetere, 2019).With age, several underlying physical changes occur, and the also risk of chronic disease rises. By age 60, the problems of disability arise from age-related losses in hearing, vision and movement, among others.

Older adults show a low adjustment to new technologies compared to younger generations either because of their present health limitations or because they do not have enough technological experience (Tidd & Bessant, 2018). This low adjustment to new technologies is related to the lack of innovation for elderly users such as a comprehensive and friendly UI design. Also, many technologies and services often are not suitable for the needs of the elderly. Moreover, in their effort to use new technology, they generally face many difficulties due to possible disabilities, education, and income, as well as difficulties related to the complexity of new technology (Roupa et al., 2010). In their effort to take greater responsibility for their physical limitations and individual health, elderly users seek easy to use technology (Ahmed Alsswey & Al-Samarraie, 2019). This paper describes the main usability issues faced by the elderly while interacting with UI, determines the requirements of UI components and develops UI guidelines for the elderly to overcome usability issues. The goal is to enable the elderly to better access technology particularly smartphone use for a positive influence on their lifestyles through improved access to applications and to support more independent living. The remainder of this paper is structured as follows: Section 2 describes the background of this study; Section 3 describes the research method; Section 4 presents the descriptive results and proposed design guidelines, Section 5 discusses the obtained results and; Section 6 presents the conclusion.

2. Background

2.1 User Interface

A user interface (UI) is defined as the visual part of a computer application or operating system in which users monitor software, applications or hardware devices (Carbune, Keysers, & Deselaers, 2019). It shows how commands are passing to the program or computer and how information is displayed on the screen. A well-designed UI offers a user-friendly design and allows users to interact with the software or hardware easily. A GUI involves common graphical controls such as menus, a toolbar, windows, buttons, icons and other controls that make it possible for people to use the software and hardware without having completely relearned the interface. It also provides a consistent user experience across multiple programs.

2. 2 Physical and cognitive challenges in the use of UI by elderly

Due to aging, older adults suffer from varying degrees of hearing loss, psychomotor impairments, poor vision as well as reduced attention, memory and learning abilities (Bayles, McCullough, & Tomoeda, 2018; Reed, 2018). In addition, many encounter challenges when interacting with their mobile phones, particularly shifting from a keypad to a touchscreen UI. The use of UI by the elderly is also influenced by declining physical abilities caused by changes in bones and muscles, as well as cognitive and sensory changes that affect movement (Vernooij, Rao, Berton, Retornaz, & Temprado, 2016). The following sections discuss these problems in detail.

2.2.1 Vision loss

The declining visual abilities experienced by the elderly make it difficult for them to perform tasks such as small font sizes, visually complex interfaces such as buttons, icons and low contrast colours (A Alsswey, Umar, & Al-Samarraie, 2018; Ruzic & Sanford, 2017). Vision is one of the most common physiological changes associated with aging. Many of the elderly will experience vision changes, including presbyopia and a loss in near vision (Khan, Petropoulos, Ponirakis, & Malik, 2017). Older adults will also experience a decline in contrast sensitivity as well as reduced colour sensitivity, particularly in the blue and green range (Thorslund & Strand, 2016). Vision loss is a result of aging produced by a drop in elasticity in the lens. Whereas the capability of the elderly to concentrate on close objects is reduced which makes it difficult to see objects clearly. Also, decreasing depth perception and light sensitivity prevent many elderly from deciding correctly where an object is located in the distance. In addition, user interface components such as font type and size, font style, background and foreground colours, patterns, and images cause eye strain and fatigue for the elderly (Yang, Mei, Xu, Rui, & Li, 2016). However, vision loss is the main healthcare problem among the elderly and correlates with a decreased capability to execute daily life activities. For example, roughly one in three elderly aged 65 and above have some form of vision-reducing eye disease(Zhao, 2018).

2.2.2 Fat fingers

“Fat finger” is defined as a human error caused by pressing the wrong key or buttons when using a computer or touchscreen to input data. When the objective is smaller than the size of the user finger contact area and interactions, it could result in the incorrect input. Most elderly users have interactions problems with UI components such as drag and drop and scrolling, and they prefer to use traditional pressing button method. According to Jin, Plocher, and Kiff (2007), to enhance the ability of use and visibility, the suitable button size should be at least 11.43 mm^2 for a single button and 16.51 mm^2 for pairs, while the horizontal distance between buttons should be between 3.17 mm to 12.7 mm. For the elderly who have a shaky hand and poor movement control, the suitable size and spacing between buttons are 16.51 mm^2 and 3.17 to 6.35 mm respectively.

2.2.3 Declined cognition

Declines in cognitive abilities and working memory frequently make it more difficult for elderly to retain new skills and learn to and use technology-based tasks (Leung, Findlater, McGrenere, Graf, & Yang, 2010; Wolfson, Cavanagh, & Kraiger, 2014). Pak and McLaughlin (2010) posited that a decrease in spatial cognition influences the ability to build the mental models required for developing and interacting with social networks via mobile devices. For example, memory is responsible for transformation and controlling information temporarily while the users execute the tasks. With memory drops due to aging, it becomes hard for the elderly group to complete tasks (Souza, 2016). Therefore, designing a usable UI enhances the utilisation of technology.

2.2.4 Low literacy level

Studies have shown a rapid decrease in learning level with the users' age regardless of their education level. As a result of aging, it is difficult to understand content, remember and learn new knowledge. The guideline suggested using clear presentation with formal and common language and familiar font type for designing friendly UI for elderly users to make it easy to learn and understand the content of the UI.

However, interfaces are mostly designed for younger users, with small screens, high-resolution displays, and relatively few buttons used to perform multiple functions (Fisk, Rogers, Charness, Czaja, & Sharit, 2009; Petrovčič, Taipale, Rogelj, & Dolničar, 2018). Researchers have recognised the scope of physical, cognitive and psychological difficulties often encountered by elderly when using technological devices such as smartphones (Fisk et al., 2009; Muriana & Hornung, 2017). These involve physical and health issues, reductions in cognitive abilities and memory, declining visual and auditory abilities in dealing with new technology.

2.2.5 Arab elderly

The number of elderly in the Arab world has increased rapidly. At present, Lebanon and Tunisia have the highest percentage of older people or those who are at least 65 years old (7.3% and 7.0%, respectively). By 2050, the proportion of elderly will exceed 20% in six out of the 22 Arab countries and will range between 12% and 19% in nine other countries (Sibai, Rizk, & Kronfol, 2014). Most Arab countries will reach the peak of their demographic dividend before 2030. This phenomenon will have implications for the labour force market, pension requirements, social security systems and health and social care costs. The significant growth in the number of elderly Arabs introduces the need to develop technologies for this user group to comply with their demands.

3 Research methodology

3.1 Research method

In the design for the elderly, we need to consider the well-known influences of aging. Fundamentally, as we age, we have increasing levels of disability, limitations and illness. Interface design needs to consider poor vision, losses in motor skills and cognition.

The UI of mobile apps consists of several design components. This study focused on UI components for visual and verbal properties (Table 1) that cause usability problems for the elderly users. These UI groups of components are based on the work of Park, Han, Kang, Park, and Chun (2011). A quantitative method was employed in this study to identify the difficulties and limitations facing Arab elderly users when using UI of mobile applications as well as UI components related to UI usage difficulties. A questionnaire was distributed to gather data from 124 participants.

Table1. UI groups

No	UI groups	Values
1	Style group	– Shape, number, font, size, border, and colour
2	Layout group	– Position or relation with other UI components such as location, distance, alignment, and grouping
3	Terminology group	– How labels should be written
4	Presentation group	– Meanings of contents, icons, images, and symbols

In order to identify the universal guidelines for designing UI for elderly users, it is important to understand the challenges facing elderly users when interacting with the UI and the related components of UI responsible for each challenge. This study consists of two phases. The first phase employed a questionnaire to identify the challenges elderly face, while the second phase identifies the UI components responsible for those challenges when using UI from which a design guideline is proposed. To achieve these objects, the mapping between elderly users' challenges and UI components is analysed. Figure 1 shows the mapping between elderly users' problems in using UI and UI components.

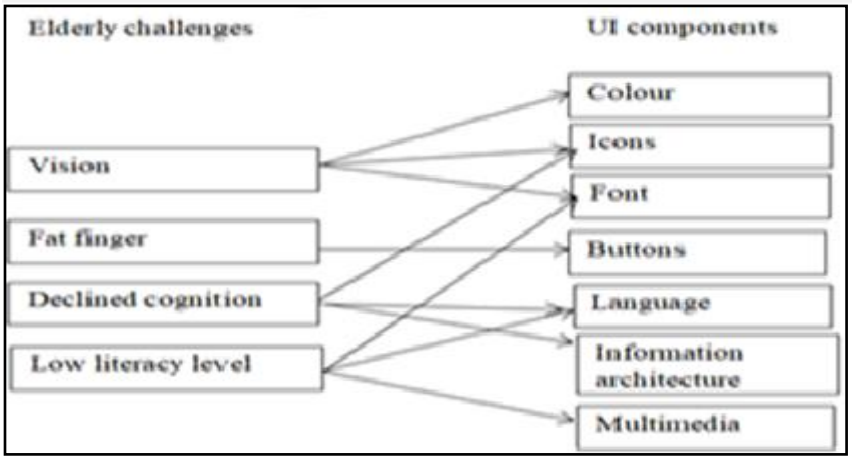

Fig. 1. Mapping between elderly challenges and UI

3.2 Questionnaire

The questionnaire for this study was modified and adopted and had been employed in the prior studies to assess user interface elements. The questionnaire was structured into three sections: section one highlighted the demographic information of participants such as age, gender, country, experience in using mobile applications, and educational qualifications. Section two was designed to identify difficulties and limitations facing Arab elderly users when using UI of mobile applications. Section three was designed to identify UI components related to UI usage difficulties. To evaluate the user interface components of the study the instrument developed by Liu, Chen, Sun, Wible, and Kuo (2010) was employed, Cronbach's was .91.

3.3 Participants

The original sample of this study was 124 elderly users from several Arab countries. the following inclusion criteria were employed for the selection of the elderly: a) aged 60 years and above; b) has at least one year experience in using mobile applications. Purposive sampling technique was carried out to gather the sample for this study to ensure that every participant had met the study criteria.

One hundred and fifty questionnaires were distributed. A total of 134 questionnaires were collected, which represent 89.3% response rate for the survey. Among the 134 of questionnaires collected 10 questionaries' were omitted due to incomplete answers for some questions. Only 124 actual questionnaires were used for data analysis. The demographic information of elderly Arab respondents is shown in Table 2.

Table 2: Demographic information statistics for participants

	Information	No. of participants	Percentage of sample
Age	60 – 64	91	73.39%
	65 – 69	24	19.35%
	70 – 74	9	7.26%
Participants' gender	Male	73	58.9%
	Female	51	41.1
Country of origin	Jordan	47	37.9%
	Palestine	38	30.6%
	Syria	19	15.3%
	Yemen	11	8.9%
	Libya	9	7.3%
Participants' education level	School level	28	22.6%
	Diploma degree	43	34.7%
	Bachelor's degree	39	31.5%
	Master's degree	11	8.9%
	PhD degree	3	2.4%
Participants' experience level in using mobile apps	1 – 3 years	4	3.2%
	4 – 6 years	58	46.8%
	7 – 9 years	45	36.3%
	≥ 10 years	17	13.7%

Table 2 shows the majority of participants were between 60-64 years (n: 91; 73.39%). Regarding gender distribution, out of the 124 participants, 73 of them (58.9%) were male and 51 (41.1%) were female. Regarding country of origin the largest number of participants were from Jordan (n: 47; 37. 9%), followed by Palestine (n: 38; 30. 8%), Syria (n: 19, 15,3%) and Yemen (n: 11; 8. 9%), while Libya recorded the lowest number (n: 9; 7. 3%). As for users' Participants' education level, the majority of participants had a diploma degree (n: 43; 34.7%), 31.5% had a bachelor's degree, 22.6% had school certificate; 8.9% had master degree, only 3 participants had a Ph.D. degree. As for users' experience with mobile applications, the majority of users (n: 58, 46.8%) had experience of between 4-6 years.

4. Results

ANOVA analysis test was employed to check the differences between design elements of UI.

Table 3. ANOVA analysis

UI components	Mean	SD	ANOVA
Colour	6.8	.59	F(1, 24)= 1.721,P=005
Font	5.7	.53	F(1, 24)= 1.542,P=001
Icons	4.6	.64	F(1, 124)= 1.784,P=006
language	4.9	.73	F(1, 124)= 1.653,P=004
Buttons	5.9	.62	F(1, 124)= 1.437,P=003
Multimedia	6.1		F(1, 124)= 1.1492,P=003
Information Architecture	6.4	.53	F(1, 24)= 2.423,P=004

An ANOVA showed significant of UI components, colour (P <.005), font (P<.001), icons (P<.006), language (P<004), buttons (P<.003), multimedia (P<003) and information architecture (P<.004).

4.1 Colour

Colours are an additional form of data, and the human eye can perceive more than ten million different colours. Colour theory helps people organise this data into convenient portions (Shneiderman & Plaisant, 2010). The elderly have less sensitivity to colour contrast than younger people. This decrement of capability applies to different ranges of colour especially in the blue-green range (Owsley, 1983; Phiriyapokanon, 2011). Therefore, using suitable contrast of colours in UI design will enhance and makes vision clearer for elderly users. For instance, using suitable contrast colours between text and background or between foreground and background, as well as avoiding using colours of similar lightness adjacent to one another regarding the wavelength makes the text and other components such as buttons and menus clear to use and readable. The use of black colour font on the white background will be a good instance for this. On the other hand, it is vital to know the contrast of colours one against another that makes them more or less discernible rather than the individual colours themselves. These are three simple rules for making effective colour choices (Sutton & Whelan, 2017).

4.2 Font

The font is a vital component in designing the UI because it has a direct influence on vision, moods, and strength (Strizver, 2014). The font is defined as a set of characters that are displayed or printed in a specific form and size (Dobres et al., 2016). The two properties of a font are its

type and size. Using common and large fonts helps users avoid confusion related to text displayed on the screen. This usage of font properties will influence learning and usage positively.

4.3 Icons

Icons play an important role in UI design and express information about functionality without using words. When the meaning of an icon is familiar to the user (e.g., a door leads to the "exit"-view), the intended context can be recognised quickly, possibly more quickly than through reading a text message or label (Fisk et al., 2009). In addition, icon size reflects positively on the elderly's vision cognition. Previous studies found that there are difficulties in recognising certain icons in different situations. For this reason, the icon itself and its size should be considered during the UI design.

4.4 Language

Language is the backbone of interaction and communication between users and UI interface and has a direct influence on the usability of any UI (Khanum, Fatima, & Chaurasia, 2012). Using formal language in displaying the text and instructions, using proper and common words in terminology and labelling buttons and menus will help the elderly in understanding the UI content clearly, avoid misunderstanding and promote the level of learning. The resulting increased usage would enhance cognitive reserve and transfer protection against the loss of brain functions.

4.5 Buttons

Using large UI components in the UI design, especially buttons, will solve issues related to "fat finger" and shaky hands. Large buttons give the elderly enough space to press target buttons correctly without mistakes (Young, 2008). Normal or small sized buttons cause the elderly to make many mistakes forcing them to start from the beginning. This consumes time and causes many users to abandon the use of applications or systems.

4.6 Multimedia

Many elderly users have difficulties reading and writing, making them unable to use the system correctly or optimally. Using multimedia in the UI design increases the memorisation of information throughout action, vision, and hearing. The user interface shared with video and audio sources will deliver a comfortable, communicative and easy environment for the users, particularly the elderly.

4.7 Information architecture

Information architecture concerns information and UI components such as buttons, icons, and layouts, to be viewed on an interface based on its importance to other visual components. With increasing age, the elderly's vision declines. Therefore, to process their environment, the elderly need a higher degree of attentiveness (Farage, Miller, Ajayi, & Hutchins, 2012). In addition, when elderly users use the system or the application, they scan the screen for certain components or content. This content should be clear and easy to find and designed simply to enhance the ability to learn using the systems. This can be achieved by aligning key information in the central visual field (Farage et al., 2012).

Table 4 summarises the guidelines for elderly users' interface design.

Table 4. UI guidelines

Problem	Guidelines
Vision	• Using the suitable contrast of colours in UI design (warm, cold) • Using suitable contrast colours between text and background or between foreground and background • Avoid using colours of similar lightness adjacent to one another • Using more than one colour to distinguish between UI components • Using large and familiar font type (i.e., sans-serif style group)
Fat finger	• Using large UI components especially buttons • 11.43 mm^2 for single button • 16.51 mm^2 for pairs • The horizontal distance arranged between buttons between 3.17 mm to 12.7 mm • For the elderly who have a shaky hand and poor movement control, the suitable size and spacing between buttons that proposed is 16.51 mm^2 and 3.17 to 6.35 mm respectively
Declined cognition	• Using simple design of UI • Using large icons • Using icons that have meaningful functions.
Low literacy level	• Using animation, video, and voice • Using formal language • Using common font type

5. Discussion

Colour is a vital aspect in UI design and a success factor of any UI. It is the first item users interact within applications and determines the communication language for end users. Therefore, choosing the proper colour with suitable contrast between UI colours will improve the ability of older people to have good vision and learning. This finding is supported by Ahmed ALsswey, Umar, and Bervell (2018), Ahmed Alsswey and Al-Samarraie (2019), A Alsswey et al. (2018) and Walton, Walton, Vukovic, and Marsden (2002). Their finding focused on using a suitable concentration of colours by suggesting using long-spectrum to determine which colour is suitable to enhance the vision of the elderly.

The font has a direct influence on UI and plays a vital role in navigation, headings, contents and other important components. Therefore, the font should be used suitably according to the purpose and role of the UI by considering its type and size. This paper finds that the font type and size have a direct impact on the vision of elderly users. This result is supported by Fisk et al. (2009). They stated that with increasing age, the ability to sharply focus on objects at low distance decreases.

As for the language, this paper argued that using formal language in UI design will increase the ability of elderly users toward using those applications and learning. Several studies support the recommendation of this paper related to this language aspect. For example, A Alsswey et al. (2018) showed that the usability of UI improves when the designer or developer of the UI considers the users' native language in the UI design.

Larger UI components can be detected more easily with a fat finger and impaired vision. In addition, the elderly need more time and mental effort to perform a pointing task when buttons are reduced in their size (Caprani, O'Connor, & Gurrin, 2012). However, they respond faster and with higher accuracy with large button size. Jin et al. (2007), and Caprani et al. (2012) recommended using large UI components by providing the suitable size of the components and space between it. This finding is supported by Holz and Baudisch (2010) who mentioned that if there are not enough space between the components of the UI, it makes it hard for the elderly to press the target button without mistakes.

Furthermore, the elderly spend a lot of time reading and using the applications because of memory loss and vision. Using multimedia in UI design decreases the time required for reading and raises the level of understanding. This recommendation is supported by Page (2014), and (Owsley, 1983) who reported that older adults favour multimedia interfaces with minimal reading regardless of their education level.

Finally, this paper stated that simple design, the display arrangement and grouping of UI components is vital to make an application friendly and easy to use for elderly users to remember the components and control information transmission. Jenkins, Salmon, Stanton, and Walker

(2010) argued that the information displayed on an interface needed to be concise and summarised accordingly.

6. Conclusion

This paper found that Arab elderly users' vision, fat finger, low literacy level, and reduced cognition were the main challenges in using UI. These challenges were affected by some UI components that should be considered by designers during UI design processes such as using convenient font type, font size, language, icons, multimedia, colour distribution, buttons and information architecture. In particular, the UI should only display vital components and content, and the unnecessary components should be omitted to facilitate its usage. Finally, friendly, simple and familiar UI design produces high usability, performance and accessibility for elderly users.

References

Alsswey, A., & Al-Samarraie, H. (2019). Elderly users' acceptance of mHealth user interface (UI) design-based culture: the moderator role of age. *Journal on Multimodal User Interfaces*, 1-11.

Alsswey, A., Umar, I., & Al-Samarraie, H. (2018). Towards mobile design guidelines-based cultural values for elderly arabic users. *J Fundam Appl Sci*, *10*(2S), 964-977.

ALsswey, A., Umar, I. N. B., & Bervell, B. (2018). Investigating the Acceptance of Mobile Health Application User Interface Cultural-Based Design to Assist Arab Elderly Users. *INTERNATIONAL JOURNAL OF ADVANCED COMPUTER SCIENCE AND APPLICATIONS*, *9*(8), 144-152.

Bayles, K., McCullough, K., & Tomoeda, C. K. (2018). *Cognitive-communication Disorders of MCI and Dementia: Definition, Assessment, and Clinical Management*: Plural Publishing.

Caprani, N., O'Connor, N. E., & Gurrin, C. (2012). Touch screens for the older user *Assistive technologies*: IntechOpen.

Carbune, V., Keysers, D., & Deselaers, T. (2019). Visual User Interface (UI) Interaction Prediction.

Dobres, J., Chahine, N., Reimer, B., Gould, D., Mehler, B., & Coughlin, J. F. (2016). Utilising psychophysical techniques to investigate the effects of age, typeface design, size and display polarity on glance legibility. *Ergonomics*, *59*(10), 1377-1391.

Farage, M. A., Miller, K. W., Ajayi, F., & Hutchins, D. (2012). Design principles to accommodate older adults. *Global journal of health science*, *4*(2), 2.

Fisk, D., Rogers, W., Charness, N., Czaja, S., & Sharit, J. (2009). Principles and creative human factors approaches: Boca Raton, Fla: Taylor and Francis Group LLC.

Holz, C., & Baudisch, P. (2010). *The generalized perceived input point model and how to double touch accuracy by extracting fingerprints.* Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.

Jenkins, D. P., Salmon, P. M., Stanton, N. A., & Walker, G. H. (2010). A new approach for designing cognitive artefacts to support disaster management. *Ergonomics*, *53*(5), 617-635.

Jin, Z. X., Plocher, T., & Kiff, L. (2007). *Touch screen user interfaces for older adults: button size and spacing.* Paper presented at the International Conference on Universal Access in Human-Computer Interaction.

Khan, A., Petropoulos, I., Ponirakis, G., & Malik, R. (2017). Visual complications in diabetes mellitus: beyond retinopathy. *Diabetic Medicine*, *34*(4), 478-484.

Khanum, M. A., Fatima, S., & Chaurasia, M. A. (2012). Arabic interface analysis based on cultural markers. *arXiv preprint arXiv:1203.3660*.

Leung, R., Findlater, L., McGrenere, J., Graf, P., & Yang, J. (2010). Multi-layered interfaces to improve older adults' initial learnability of mobile applications. *ACM Transactions on Accessible Computing (TACCESS), 3*(1), 1.

Liu, I.-F., Chen, M. C., Sun, Y. S., Wible, D., & Kuo, C.-H. (2010). Extending the TAM model to explore the factors that affect Intention to Use an Online Learning Community. *Computers & Education, 54*(2), 600-610.

Muriana, L. M., & Hornung, H. (2017). *Towards Participatory Prototyping with Older Adults with and without Cognitive Impairment: Challenges and Lessons Learned.* Paper presented at the IFIP Conference on Human-Computer Interaction.

Neves, B. B., & Vetere, F. (2019). *Ageing and digital technology: designing and evaluating emerging technologies for older adults*: Springer.

Owsley, N. L. (1983). High resolution spectrum analysis by dominant mode enhancement: NAVAL UNDERWATER SYSTEMS CENTER NEW LONDON CT NEW LONDON LAB.

Page, T. (2014). Touchscreen mobile devices and older adults: a usability study. *International Journal of Human Factors and Ergonomics, 3*(1), 65-85.

Park, W., Han, S. H., Kang, S., Park, Y. S., & Chun, J. (2011). A factor combination approach to developing style guides for mobile phone user interface. *International Journal of Industrial Ergonomics, 41*(5), 536-545.

Petrovčič, A., Taipale, S., Rogelj, A., & Dolničar, V. (2018). Design of mobile phones for older adults: An empirical analysis of design guidelines and checklists for feature phones and smartphones. *International Journal of Human–Computer Interaction, 34*(3), 251-264.

Phiriyapokanon, T. (2011). Is a big button interfaceenough for elderly users?: Towards user interface guidelines for elderly users.

Reed, H. (2018). The Psychosocial Effects of Hearing Loss on Adults.

Roupa, Z., Nikas, M., Gerasimou, E., Zafeiri, V., Giasyrani, L., Kazitori, E., & Sotiropoulou, P. (2010). The use of technology by the elderly. *Health Science Journal, 4*(2), 118.

Ruzic, L., & Sanford, J. A. (2017). *Usability of mobile consumer applications for individuals aging with multiple sclerosis.* Paper presented at the International Conference on Universal Access in Human-Computer Interaction.

Shneiderman, B., & Plaisant, C. (2010). *Designing the user interface: strategies for effective human-computer interaction*: Pearson Education India.

Sibai, A., Rizk, A., & Kronfol, N. (2014). Ageing in the Arab region: Trends, implications and policy options. *Center for Studies on Aging (CSA), ESCWA and UNFPA. Retrieved from http://csa. org. lb/cms/assets/csa% 20publications/unfpa, 20*.

Souza, A. S. (2016). No age deficits in the ability to use attention to improve visual working memory. *Psychology and aging, 31*(5), 456.

Strizver, I. (2014). *Type Rules, Enhanced Edition: The Designer's Guide to Professional Typography*: John Wiley & Sons.

Sutton, T., & Whelan, B. M. (2017). *The Complete Color Harmony, Pantone Edition: Expert Color Information for Professional Color Results*: Rockport Publishers.

Thorslund, B., & Strand, N. (2016). Vision measurability and its impact on safe driving: a literature review. *Scandinavian Journal of Optometry and Visual Science, 9*(1), 1-9.

Tidd, J., & Bessant, J. R. (2018). *Managing innovation: integrating technological, market and organizational change*: John Wiley & Sons.

Vernooij, C. A., Rao, G., Berton, E., Retornaz, F., & Temprado, J.-J. (2016). The effect of aging on muscular dynamics underlying movement patterns changes. *Frontiers in aging neuroscience, 8*, 309.

Walton, M., Vukovic, V., & Marsden, G. (2002). *'Visual literacy'as challenge to the internationalisation of interfaces: a study of South African student web users.* Paper presented at the CHI'02 extended abstracts on Human factors in computing systems.

Wolfson, N. E., Cavanagh, T. M., & Kraiger, K. (2014). Older adults and technology-based instruction: Optimizing learning outcomes and transfer. *Academy of Management Learning & Education, 13*(1), 26-44.

Yang, X., Mei, T., Xu, Y.-Q., Rui, Y., & Li, S. (2016). Automatic generation of visual-textual presentation layout. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM), 12*(2), 33.

Young, P. A. (2008). Integrating culture in the design of ICTs. *British Journal of Educational Technology, 39*(1), 6-17.

Zhao, T. (2018). *Designing a Mobile Reading User Interface for Aging Populations.* Kent State University.